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702

WAYNE KERR

ESL

AF VOLTMETER

M121

PROVISIONAL HANDBOOK

Serial No. 227

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A F V O L T M E T E R

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PROVISIONAL HANDBOOK

Serial No. 227

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Fig. 1 Block Diagram

Circuit Diagram

Measured values of 600Ω and 100K input impedance

I N T R O D U C T I O N

This instrument is an extremely stable valve-voltmeter for measuring audio- and low radio-frequency signals to an accuracy of better than one per cent. A cathode-follower output stage is incorporated to permit use of the instrument as a feed-through amplifier.

Full-scale ranges are from 1 millivolt to 100 volts r.m.s. and relative levels can be measured from -70 to +22 decibels on a reference of 1 milliwatt into 600 ohms. An incremental control enables a discrimination of better than 0·05dB to be obtained.

The input impedance is 1 megohm on the 30 and 100-volt ranges and is not less than 15 megohms on all other ranges. Facilities for balanced inputs are provided at 100,000 ohms and 600 ohms impedance.

Readings are displayed on an individually-calibrated moving-coil meter with a scale length of six inches. A mirror is provided to eliminate parallax errors. No set zero adjustments are necessary.

S P E C I F I C A T I O N

Power Requirement:

100/115, 190/220V or 220/250V, 50-60 c/s. Consumption approximately 50 watts.

Full-scale Ranges:

1, 3, 10, 30, 100 and 300 millivolts, r.m.s.
1, 3, 10, 30, and 100 volts, r.m.s.

Relative Levels:

Meter calibrated for relative levels from -70dB to + 22dB on a reference level of 1mW into 600Ω. Incremental dB control, calibrated from -0·5 to + 0·5dB in 0·1dB steps, provides increased reading accuracy.

Input Impedance:

Direct Input x 1 (1 mV-10 V ranges)

Not less than 15 Megohms in parallel with 20pF at the terminals.

Direct Input x10 (30 V and 100 V ranges)

1 Megohm in parallel with 20pF at the terminals.

Transformer Input (1 mV-10 V ranges)

600 ohm and 100,000 ohm balanced or unbalanced. Transformer open-circuit primary inductance at least 25H.

Accuracy:

Direct Input x 1

Better than 1 per cent of full-scale deflection from 20 c/s to 100 kc/s.
Better than 2 per cent at 200 kc/s.
Better than 5 per cent at 300 kc/s.

Direct Input x10

1 per cent up to 100 kc/s.
Better than 5 per cent up to 300 kc/s.

Transformer Input

Better than 1 per cent of full-scale deflection from 20 c/s to 20 kc/s for source impedance up to 1,000 ohms.

Residual Reading:	20 μV r.m.s. due to hum and noise.
Amplifier Output:	Facility for using the voltmeter as a feed-through amplifier. With 1mV input, maximum effective gain is 60dB. Output 1 volt available from cathode-follower. Output impedance approximately 500 ohms at 1kc/s. The frequency response is similar to that obtained when the instrument is used as a voltmeter.
Indication:	Moving-coil meter, with knife-edge pointer and mirror. Meter scale length 6 inches. Three scales, each individually calibrated: 0-3 and 0-10 for all voltage ranges, -10 to +2dB for relative levels.
Dimensions:	Width 17 in. (43 cm). Height $11\frac{1}{2}$ in. (29 cm). Depth $10\frac{1}{4}$ in. (26 cm).
Weight:	33 lb (15 kg).

C I R C U I T D E S C R I P T I O N

A block diagram of the voltmeter is shown in Fig. 1 and a complete circuit diagram is provided at the back of this book.

STABILIZED POWER SUPPLY

Stabilization and smoothing are provided by a series control valve (VA), a reference valve (VC) and a cascode-connected double triode (VB) serving as the difference amplifier. H.T. is applied to the anode of the series control valve from the full-wave rectifier V9. The stabilized voltage output from the cathode of the series control valve is set to 275 volts by RVA.

INPUT AMPLIFIER and INPUT SELECTOR

This consists of a voltage-amplifying stage (V1), a phase inverter (V3a) and a cathode-follower comprising the paralleled sections of V3b, V4a and V4b.

The grid circuit of V1 includes a four-position switch, Input Selector, S1.

In the fully counter-clockwise position of the Input Selector, labelled '100K', the input to V1 grid is from the secondary of the 1:1 transformer, T1, which has an open-circuit primary inductance of not less than 25 henrys. The secondary is loaded with a resistance of 100kΩ. The primary is isolated from the chassis and is connected to the tip and ring contacts of the Transformer Input Jack. The sleeve contact of this jack is connected directly to chassis. The input level to the transformer should not exceed 10 volts r.m.s. A d.c. potential must <u>not</u> be applied across the input to the transformer, but the complete primary winding can be operated with a d.c. potential difference to

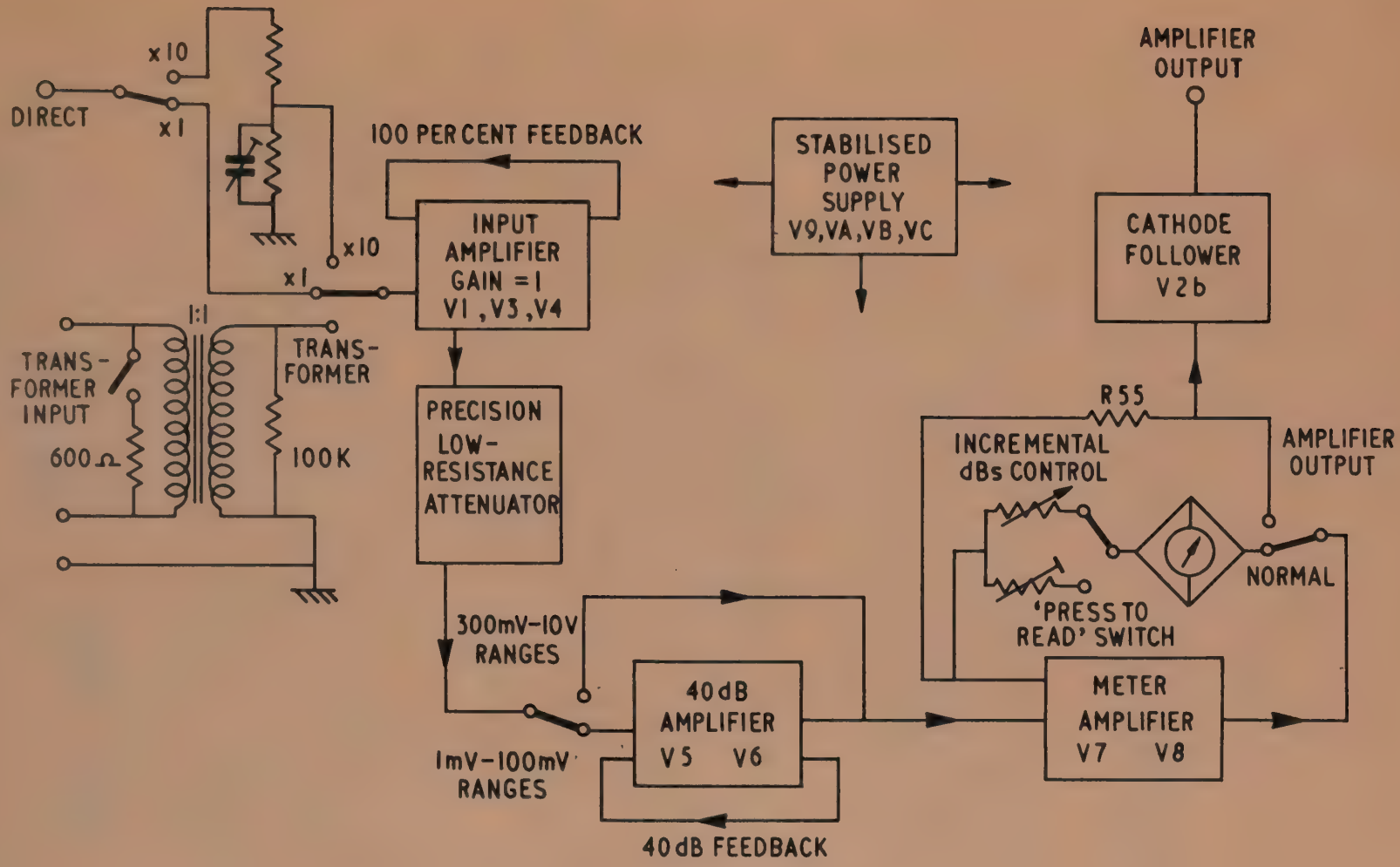

FIG. 1 M121 BLOCK DIAGRAM

chassis provided that this does not exceed ± 250 volts.

In the '600Ω' setting of the Input Selector the arrangement is the same as on '100K' except that a 600-ohm resistor is switched into circuit across the transformer primary.

In the 'x1' setting of the Input Selector, V1 grid circuit is connected to the Direct terminal. A blocking capacitor (C1) is incorporated in the instrument but the signal applied to the Direct terminal should not contain a d.c. component in excess of 250 volts relative to chassis. The input impedance in this condition is not less than 15 megohms in parallel with 20pF at the terminals.

In the 'x10' setting of the Input Selector a resistance of 1 megohm, with no d.c. blocking, is connected between the Direct terminal and chassis. The effective resistance of V1 grid circuit constitutes 100,000 ohms of this resistance, and consequently, one-tenth of the a.f. voltage applied to the Direct terminal appears at the grid of the Input Amplifier. The 3-volt and 10-volt ranges are thereby extended to full-scale ranges of 30 and 100 volts r.m.s. A trimmer capacitor (C4) compensates for the effect of stray capacitance across R1.

PHASE INVERTER

The output from V1, the voltage amplifier, is applied directly to the grid of the phase inverter, V3a. The direct coupling prevents any phase-shift occurring at low frequencies. The cathode resistors for V3a are so chosen that correct bias for V3a is obtained, allowing for the d.c. potential on its grid. One cathode resistor is not bypassed, the

resulting negative feedback ensuring a linear response over a wide frequency range.

CATHODE FOLLOWER

V3b, V4a and V4b are connected in parallel to form a cathode-follower stage of low output impedance. 100 per cent negative feedback over the complete input amplifier is obtained by connecting the output from the cathode-follower directly to V1 cathode. This feedback provides V1 with a very high input impedance and a low-impedance cathode circuit. The overall gain of the input amplifier is very slightly less than unity.

RANGE SWITCH

The Range switch (S2) is associated with tappings on a resistive chain (R10-R14) in V1 cathode circuit. As this circuit is of low impedance, small value resistors can be used and, therefore, no frequency-compensating capacitors are necessary. Metal-film resistors are used, resulting in a non-reactive and very stable attenuator circuit. The resistors have a tolerance of 0·2 per cent and an extremely low temperature coefficient, ± 0·0025 per cent/°C. The d.c. path to chassis for V1 cathode circuit is provided by R16 and no d.c. is passed through the chain R10-R14. Thus there are no transients on changing range.

When the Range switch is in any position from 1mV to 100mV, the signal tapped off from V1 cathode circuit is applied first to the 40dB amplifier constituted by V5 and V6, and subsequently to the meter amplifier V7 and V8.

When the Range switch is in any position from 300mV to 10V, the signal tapped off from V1 cathode circuit is applied direct to the meter amplifier V7 and V8.

40dB AMPLIFIER

The amplifier V5, V6, has a gain of 100 (40dB), and 40dB negative feedback is applied from V6 anode to V5 cathode. The gain is adjusted to the exact value by a pre-set resistor (RV2) in the feedback circuit. The high degree of negative feedback results in the gain varying only very slightly with wide changes in valve or component tolerances, and also ensures a wide frequency response.

METER AMPLIFIER

The final amplifier in the voltmeter consists of V7 and the paralleled sections of V8a and V8b. The meter bridge rectifier circuit is connected in a current negative feedback loop from V8 anode to V7 cathode circuit. The overall gain of the meter amplifier is adjusted by a pre-set resistor (RV4) in V7 cathode circuit to such a value that an input of 100 millivolts r.m.s. to V7 grid results in a rectifier current of 1 milliamp, giving full-scale deflection on the meter.

INCREMENTAL DECIBEL CONTROL

The Incremental dB control consists of a variable resistor (RV3) in V7 cathode circuit, and it is brought into operation only when the 'Press To Read' micro-switch is operated. Adjustment of RV3 provides a small variation in the overall gain of the meter amplifier.

METER and
BRIDGE RECTIFIER

The bridge rectifier consists of four germanium diodes (MR1 - MR4). These rectify the alternating current fed back from V8 anode to V7 cathode. circuit. By incorporating the rectifying elements in a current feedback circuit, a linear relationship between the input voltage to the meter amplifier and the meter current is ensured.

The meter is a moving-coil instrument with a basic movement of 1mA at full-scale deflection and a scale length of six inches. The scales are

calibrated individually on each meter. Three scales are provided: 0-3 and 0-10 for all voltage ranges, and -10 to +2dB for relative levels. High reading accuracy is ensured by the provision of a mirror scale and a knife-edge pointer. The meter has the usual mechanical zero adjustment but no electrical zero-setting is necessary.

AMPLIFIER OUTPUT

The Amplifier Output jack provides the facility for use of the voltmeter as a feed-through amplifier. When a jack plug is inserted, the output from V8 is disconnected from the bridge rectifier circuit and the current feedback loop is instead completed by the resistor R55. The output from V8 is applied to the grid of a cathode-follower (V2b) and the a.c. output from this stage is applied to the tip contact of the jack.

The Amplifier Output jack is of the same type as the Transformer Input jack, and the jack plug used should be of the type with a tip, ring and sleeve.

Up to a level of 1 volt r.m.s., the amplifier output is proportional to the voltmeter input. With an input of 1mV to the instrument, the maximum gain available is 60dB. The output impedance at the jack is approximately 500 ohms at 1 kc/s.

O P E R A T I O N

VOLTAGE ADJUSTMENT

The voltmeter is suitable for operation from a.c. supplies of 110/250 volts, 50-60 c/s. Three tappings are provided: 100/115V, 190/220V and 220/250V. The tapping in use is shown in a small illuminated window in the front panel and is adjusted, from the front,

with a screwdriver.

The power cable should be connected to a three-pin plug (Green to Earth, Black to Neutral and Red to Live) and the instrument switched on for 10 minutes before measurements are made. The illuminated voltage tapping panel serves also as a reminder that the instrument is switched on.

INPUT LEADS

It must be borne in mind that the voltmeter has a high sensitivity. Consequently, if voltages across high impedances are to be measured, the use of screened leads is essential to prevent pick-up causing spurious readings. If twin screened leads are used, the braid should be connected to chassis at the voltmeter end of the lead only.

NORMAL OPERATION (x 1)

Normal operation of the instrument, when a high input impedance is required (not less than 15 megohms), is obtained with the Input Selector set to 'x 1' and the input applied between the Direct and chassis terminals. The input impedance is not dependent of the setting of the Range switch. This switch should therefore be turned to the lowest voltage range that can be used without overloading the meter, thus ensuring maximum reading accuracy. The meter scale to be read (0-3 or 0-10) and the units of the measurement are determined by the Range switch setting.

30V and 100V RANGES (x10)

If the voltage to be measured exceeds 10 volts r.m.s., the Range switch should be set to '3V' or '10V', and the Input Selector set to 'x10'. The input impedance in this condition is 1 megohm in parallel with 20pF at the terminals.

The 'x10' facility is not available on the Transformer Input, the highest range being 10 volts r.m.s.

TRANSFORMER INPUT

If the alternating voltage to be measured is balanced with respect to chassis, it should be applied to the tip and ring of a jack plug (the sleeve providing a chassis connection) and the plug inserted in the Transformer Input jack. The input impedance to the transformer is 100kΩ, but an alternative position of the Input Selector connects a 600-ohm resistor across the transformer primary.

RELATIVE LEVELS

Relative levels are with reference to 1 milliwatt into 600 ohms (this corresponds to 0·775V r.m.s.). If the voltage source is terminated (externally to the voltmeter) in 600 ohms, the Input Selector should be set to '100K'. If the source is unterminated, the Input Selector should be set to '600Ω'. Every division on the dB scale is calibrated individually and accurate interpolation is provided by the Incremental dB control, which is calibrated from -0·5dB to +0·5dB. The control is not in circuit unless the 'Press to Read' micro-switch is operated. Use of the control is described by means of an example.

Suppose that, with the Range switch set to -20dB, the meter deflection is to the left of the -6dB mark (that is, a negative reading exceeding 6dB) but is less than -6·5dB. The Incremental dB control should be set to '0', the 'Press to Read' switch operated and the control turned clockwise to bring the meter reading precisely to the -6·5dB mark. Suppose this occurs with the Incremental dB control set at +0·35dB. The relative level of the input to the voltmeter is therefore -20 -6·5 + 0·35dB, which is equal to -26·15dB.

It is not essential for the Incremental control to be set initially to 0. Provided that the initial and final settings are noted, the increment required is obtained by taking the difference between these two settings. If the Incremental dB control has been rotated clockwise, the difference between the initial and final settings should be added to the final meter reading. Conversely, when the control has been rotated counter-clockwise, the difference between the initial and final settings should be subtracted from the final meter reading.

FEED-THROUGH AMPLIFIER

The Amplifier Output jack is designed to accept a plug having a tip, ring and sleeve. When the plug is inserted, the meter is disconnected from the amplifier circuits. The amplifier output is instead coupled to a cathode-follower and the output from this is connected to the tip contact of the jack. Ring and sleeve contacts are connected to chassis. D.C. blocking and a 1-megohm leak resistor are incorporated in the instrument. The output impedance is approximately 500 ohms and up to 1 volt r.m.s. is available without distortion.

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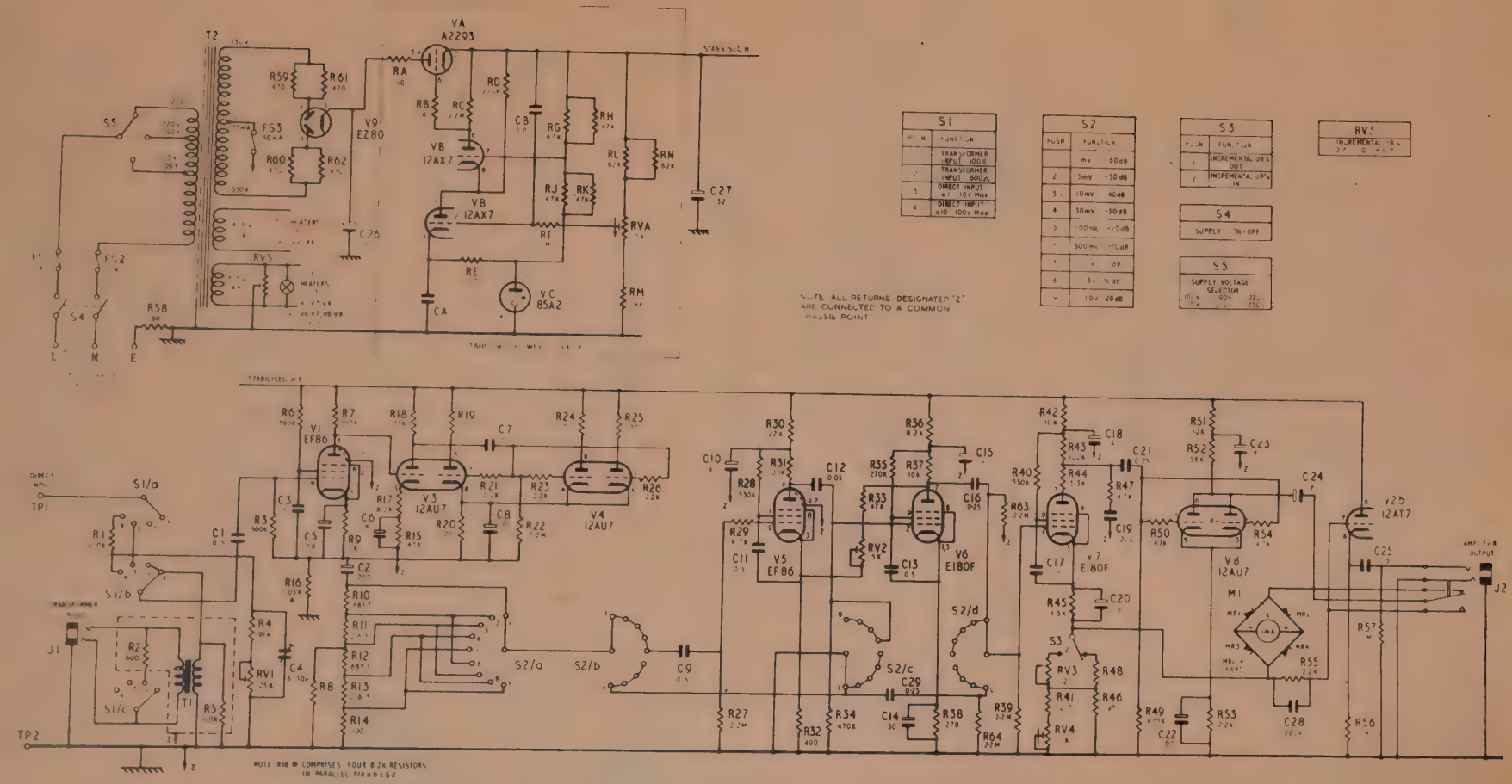

A.F. VOLTMETER (M121) CIRCUIT DIAGRAM (D5200/K)·

A.F. V O L T M E T E R M121

Serial Number 227

For the majority of applications the input impedance of the instrument can be taken as 600 ohms or 100K (on the appropriate switch settings) and these values used in establishing the reference level for relative measurements. The high accuracy available makes possible more precise measurements when these are needed. In such instances the measured values of the input impedance will be required.

For this instrument the figures are:

600-ohm input	ohms
100K input	K

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